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Technology Implementation in the Process of Higher Education: Issues and Opportunities

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Abstract

The digitalization of higher education is one of the key components of the global educational transformation, which ensures accessibility, flexibility and personalization of learning. In the context of the development of the information society and the growing role of digital technologies in ensuring the competitiveness of graduates, the issue of effective integration of digital tools into the educational process is becoming particularly relevant. The purpose of the study is to analyze the current state, challenges and prospects of integrating digital technologies into the higher education process in Ukraine. The methodological basis of the work is a systematic approach that allows us to consider the digitalization of education as a complex process of transformation of all components of the educational environment, using the methods of content analysis of scientific sources, comparative analysis of international practices and generalization of empirical data. The study identifies the main areas of digitalization of higher education in Ukraine, including the introduction of learning management systems (LMS), the development of blended learning, the creation of electronic learning environments, and the use of artificial intelligence to personalize learning. The author identifies key barriers to digitalization, including insufficient digital competence of individual teachers, limited funding, uneven access to quality Internet, and the lack of a unified digital educational ecosystem. Particular attention is paid to analyzing the impact of global crises, in particular the COVID-19 pandemic and the military actions in Ukraine, on accelerating digital transformation in higher education. The practical significance of the results obtained is to develop recommendations for improving the efficiency of digital transformation of higher education institutions, in particular through the development of digital competencies, the creation of a single national online learning platform and the introduction of mechanisms for monitoring the quality of the digital educational environment. The presented comprehensive approach to the analysis of digitalization can be used as a basis for the formation of strategic directions for the development of higher education in Ukraine in the digital era.

Keywords: *digitalization of education, higher education, digital technologies, blended learning, LMS, digital competencies, artificial intelligence, digital transformation*

JEL classification: I23, O33, P36

Introduction

The rapid development of digital technologies is fundamentally changing all spheres of social life, including the educational space. Universities, as key institutions for the formation of human capital, have faced the need not only to adapt the educational process to new conditions, but also

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to comprehensively rethink approaches to learning, teaching, and management of educational resources. Digitalization of higher education is not just a tendency but an objective requirement imposed by requirements of the global information society, an increasing role of online education, and a necessity of nondiscrimination in access to high quality educational services depends on the place of their location. In the context of Ukraine, where digital transformation of education and consequences of the COVID-19 pandemic and socio-economic threats of the military operations are held simultaneously, these processes are especially important. The involvement of the digitalization issue in higher education has been actively researched both in Ukraine and abroad in recent decades. Especially, researchers are concerned with the adoption of learning management systems (LMS), reform of blended forms of learning, design personalized learning pathways, and monitoring students' performance by the use of artificial intelligence (Reimers & Marmolejo, 2022; Benavides et al., 2020; Martin & Xie, 2022). Researcher also emphasize on developing digital competencies of both students and teachers, creating adaptive learning environment, and integrating innovative technologies like virtual reality, augmented reality, gamification in learning process (Yu & Wang, 2024; Matome & Jantjies, 2021; Andreas, 2024).

Thereafter, many aspects of digitalization of higher education are overly ignored. In particular, the given issues need to be addressed further: on the one hand, about the effective integration of digital platforms into the structure of educational process of Ukrainian universities, as well as their peculiarities related to regional and sectoral characteristics. Thus, mechanisms for ensuring digital security, the protection of personal data, and carrying out a full-scale monitoring of the effect of the use of digital technologies on the quality of the educational process are not sufficiently disclosed. Moreover, there is still no single national digital educational ecosystem currently existing in which all higher education institutions in Ukraine would be gathered in one space of access to educational resources, tools and platforms.

The **aim** of this study is to illustrate the peculiarities of the integration of the digital technologies into the higher education process in Ukraine through the highlighting of key challenges, barriers and the prospects of the digital transformation of the educational process. To achieve this goal, the following tasks are expected to be solved: to characterize global trends in the digitalization of higher education; to study the current state and features of the introduction of digital technologies in higher education institutions of Ukraine; to identify the main problems and barriers to digitalization; to analyze the best practices of digital technology integration in the world's leading universities; to offer recommendations for improving the efficiency of digital transformation of higher education in Ukraine.

Analysis of the latest research and publications

The domestic and international scientific space for study is actively dealing with digitalization of higher education, as is the integration of digital technologies into higher education, due to its becoming a strategic direction of universities development in the conditions of the global educational trends and requirements of the modern labour market (Reimers & Marmolejo, 2022; Benavides et al., 2020; Matviichuk, Yeromenko, Gladchenko, and Taran, 2021). There have been a number of studies regarding the significance of implementing learning management systems (LMS); learning platforms for learning via synchronous and asynchronous methods, and the use of adaptive systems in the domain of personalized learning (Al-Hunaiyyan, Al-Sharhan, & Alhajri, 2020; Yu & Wang, 2024; Andreas, 2024). Blended learning and the development of

competency based educational simulations are of particular interest for bringing the learning process to the proximity of companies' real world production environment conditions (Babenko, Dotsenko, & Gorbenko, 2022; Dotsenko, 2021; Soloviev et al., 2021). In the context of increasing teacher's and students digital competence, digital transformation of university constitutes a significant contribution to various studies related to (Kapranov, Bokhonko, & Cherednyk, 2022; Batsurovska, et al 2021; Abraham 2023).

In parallel, the international crises, such as the COVID–19 and the military action, are being studied separately (including using case study methodology) on how it accelerates the digital transformation of higher education system in Ukraine and the world (Reimers & Marmolejo, 2022; Matviichuk, et al., 2021; Mojumder, Uddin, & Dey, 2025). As a result of these changes, almost the entire distance learning teaching has been instituted and digital libraries, online communication platforms and automated assessment systems have been brought forth (Benavides et al., 2020; Jemni, Kammoun, Marrakchi, and Chaabouni, 2024). An important issue that accompanies the problem of lack of access to digital resources, low digital literacy of some categories of teachers and students, and insufficient funding for digital transformation in Ukraine (Vovk, 2020; Nesterenko et al., 2024; Kapranov et al., 2022). Further, matters related to the development of artificial intelligence in education, virtual and augmented realities in curricula and the occurrence of Learning Analytics for monitoring student performance are also receiving attention in the international context (Matome & Jantjies, 2021; Yu & Wang, 2024; Tan, Rudolph, & Tan, 2024).

Foreign experience also suggests the efficiency of the implementation of unified digital ecosystem containing educational platforms, analytical systems and administrative services in one space, which makes it possible to increase the quality of educational process and its flexibility (Kerimbayev et al. 2023; Woo 2024; Montgomery 2020). New studies indicate that it is both innovative technologies augmented with pedagogical methods that enables the establishment of realistic elements of digital educational space (Martin & Xie, 2022; Salam et al., 2019). Scholars also call upon the creation of national digitalization strategies that taking into account specific features of the Ukrainian educational system, in particular, equal freedom of technology access, creation of a single national educational platform, the formation of a digital Ukrainian higher education culture (Odaiskyj, 2019; Vovk, 2020; Nesterenko et al., 2024). This combination of these approaches allows us to conceive of the digital transformation of education under an holistic organization consisting of technological, organizational and pedagogical innovations.

Furthermore, in studies, also the effectiveness of e-learning is gauged according to the technological models, in particular to the Technology Acceptance Model (TAM) and TPCK framework, which also enables a complete appraisal of the readiness on the part of teachers and students to use electronic means (Mousa, Zaid, & Mohammed, 2024). In the light of the requirements of training specialists for the innovative industries, some works are devoted to the issue of ensuring sustainable development through the use of digital technologies in STEM education (Nesterenko et al., 2024). One of the studies is in the problem of studying pedagogical technologies of organization of students' learning activities in the professional education of engineers as information resources and as the tools for formation of creative and practical competencies (Nagayev et al., 2021). In this context, research also covers the analysis of the peculiarities of the formation of professional competencies in future specialists in the current conditions of transformation of the higher education system (Odaiskyi, 2019).

Special attention in modern research is paid to the issues of comprehensive transformation of universities in the context of the digital economy, where digital technologies are considered as a tool for increasing the competitiveness of educational institutions (Bak & Papalexi, 2024; Fornasiero & Tolio, 2024). Considerable attention is paid to the development of adaptive learning environments based on personalized educational trajectories created through big data analysis and artificial intelligence (Wu, Liu, & Liang, 2024). Research on leadership in the context of digital transformation and the need to develop new management approaches in higher education institutions also remains relevant (Di Nardo et al., 2025; Tan, Rudolph, & Tan, 2024). The international context emphasizes the importance of shaping the digital culture of universities, in particular through the development of digital competencies of teachers and students, the creation of flexible digital ecosystems, and the adaptation of curricula to the requirements of the digital age (Martin & Xie, 2022; Kerimbayev, Umirzakova, Shadiev, & others, 2023). The experience of Southeast Asian countries, in particular Malaysia and the Philippines, where the digitalization of higher education is combined with adaptation to the cultural and socio-economic characteristics of the region, requires special attention (Chao, 2023; Mohd Zain et al., 2017). The importance of the realization of creative and professional competencies of students in an innovating environment in the process of training engineers should be noted in this context (Nagayev et al., 2021).

It can be seen that educational systems in Southeast Asia continue to develop actively, on their basis digital technologies are used to create an adaptive and inclusive educational environment (Chao, 2023). I refer in particular to the need of digitalization and combining with the socio cultural process of the educational process to enhance its effectiveness in the context of Malaysia (Mohd Zain, Aspah, Abdullah, & Ebrahimi, 2017). Salam et al. (2019) pay special attention to service learning as a component of digital transformation, which contributes to the formation of students' social responsibility through the use of online platforms for participation in volunteer and socially useful projects. Such approaches are actively developing within the concept of learning by doing, which is becoming especially important in the digital age (Abraham, 2023).

Thus, current research confirms that the digitalization of higher education is not only a technological but also a pedagogical, socio-cultural and organizational process that requires integrated approaches to implementation. At the same time, despite the active development of digital technologies in higher education, the issues of systematic monitoring of the quality of digital learning and the effectiveness of its impact on educational outcomes, as well as the creation of a universal national platform with open educational resources for all levels of higher education, remain insufficiently addressed.

Research Methods

The study was conducted using a set of interrelated methods that provided a comprehensive analysis of the processes of digital technologies integration in the field of higher education in Ukraine and the world. In particular, theoretical methods were used, including the analysis and synthesis of scientific sources, regulatory documents, and international reports on the digitalization of the educational process, which made it possible to identify the main directions, challenges, and trends in the introduction of technologies in higher education institutions. To obtain empirical data, a questionnaire survey was conducted among students and teachers of the National University of Life and Environmental Sciences of Ukraine in February 2025. The survey covered 220 undergraduate students of various specialties and 80 teachers of humanitarian,

technical and natural science departments. The sample was formed on the basis of voluntary participation, and data was collected using Google Forms. The results of the survey were summarized and processed using quantitative analysis methods (calculation of averages, graphing, and comparative analysis). To interpret and compare the results, the method of comparative analysis was used, which made it possible to compare the data obtained with the results of similar studies by domestic and foreign authors, to identify general trends and specific features of the digitalization of higher education in Ukraine.

Research Results

The digitalization of the educational process in higher education institutions is one of the key trends in the current stage of development of the global education system. Compared to merely utilizing conventional printing technologies, digital technologies, when integrated, have the potential to improve the quality of education, personalizing the educations process, and access to educational resources. Finally, current introduction of technologies is also associated with challenges, stemming from both technological and organizational reasons.

1. Global trends in the digitalization of higher education. For several decades, the global educational community has been observing a steady trend towards the introduction of digital technologies in all stages of the educational process. This process was especially accelerated during the COVID-19 pandemic, which forced higher education institutions around the world to quickly switch to distance and hybrid forms of education (Reimers & Marmolejo, 2022).Today, the key trends in digitalization are:

• Implementation of learning management systems (LMS) that provide centralized storage of training materials, automated knowledge testing and feedback (Al-Hunaiyyan, Al-Sharhan & Alhajri, 2020).

• The use of blended learning, which combines traditional classroom classes with online components (Babenko, Dotsenko & Gorbenko, 2022).

• The use of artificial intelligence to personalize the educational process, adapt the content of training courses and automate assessment (Andreas, 2024).

• The growing popularity of virtual and augmented reality in the training of technical and medical specialists, which allows creating simulation environments for practicing practical skills (Matome & Jantjies, 2021).

• Development of gamification as a means of increasing student motivation (Yu & Wang, 2024).

2. *Digitalization of Higher Education in Ukraine: Challenges and Specifics. Ukraine's higher education system is also actively moving toward digital transformation, but this process has a number of national peculiarities and barriers. One of the main challenges is the different levels of digital competence of teachers and students, which hinders the full use of modern technologies in the educational process (Kapranov, Bokhonko & Cherednyk, 2022).*

It is also worth noting:

• Insufficient funding for higher education institutions, which makes it difficult to purchase modern software, equipment, and conduct digital trainings for staff (Matviichuk et al., 2021).

• Infrastructure problems, such as unstable access to high-speed internet in regional higher education institutions (Vovk, 2020).

• The growing role of government programs to support the digitalization of education, which are aimed at developing national online learning platforms and creating open electronic resources (Nesterenko et al., 2024).

• At the same time, some areas are actively developing in Ukraine:

• Creation of e-learning environments with integrated tools for monitoring student learning (Batsurovska et al., 2021).

• Development of competency-based educational simulators for technical disciplines that bring learning closer to real-world production conditions (Dotsenko, 2021).

• Integration 3D modeling in educational process of technical specialties. (Soloviev et al., 2021).

3. The impact of global crises on the digitalization of education. Particularly during the COVID 19 pandemic and the Russian military aggression against Ukraine, this digital transformation of the Ukrainian higher education happened in a Global crises context. These events have proved to be a strong motor force for:

• Rapid deployment of distance learning platforms and digital libraries (Mojumder, Uddin & Dey, 2025).

• Increased attention to digital security and personal data protection in the process of distance learning (Jemni et al., 2024).

Intensification of international cooperation between Ukrainian universities and the partners of the foreign parties to identify new ways of experience sharing in the field of digital transformation (Benavides et al., 2020).

Consequently, digital technologies are an absolute must for the integration of universities into the modern requirements of the knowledge society and the global labour market. The Ukraine process has to be systematic: developing national digital educational ecosystem, increasing the digital literacy of teachers and students, as well as creating appropriate conditions for institutional innovation on of each higher education institution level.

Modern educational transformation requires a component of the integration of digital technologies for the educational process of higher education institutions. Nonetheless, there are a number of problems and barriers associated with this process which hinder the implementation of such technologies in the daily activities of universities. Such problems can be identified and put in systematization; it allows us to come up with effective recommendations for the further improvement of the digital educational environment. The key problems and barriers to the introduction of digital technologies in higher education institutions are presented in Table 1.

Table 1. Key problems and barriers to the introduction of digital technologies in higher education institutions

№	Problem / Barrier	Characteristics
1	Low level of digital competencies	Some teachers and students do not have the necessary skills to effectively use digital platforms and tools (Kapranov, Bokhonko & Cherednyk, 2022).
2	Limited funding	Insufficient investment in hardware, software, and staff development (Matviichuk et al., 2021).
3	Uneven access to the Internet	This is especially true for regional and remote higher education institutions, where the quality of network connection remains low (Vovk, 2020).
4	Resistance to change on the part of teachers	Some educators perceive digitalization as a threat to traditional teaching approaches (Reimers & Marmolejo, 2022).
5	Mismatch of curricula	Existing educational programs are often not adapted to the use of modern digital technologies and methods (Nesterenko et al., 2024).
6	Lack of a unified digital ecosystem	The introduction of individual technologies takes place without a systematic approach and integration with other platforms (Benavides et al., 2020).
7	Digital security issues	Low level of protection of personal data and educational resources on some online platforms (Jemni et al., 2024).
8	Low student motivation	Some students do not perceive online courses as a full-fledged alternative to classroom classes (Mojumder, Uddin & Dey, 2025).
9	Technical difficulties in implementing VR/AR	High cost of equipment and lack of methodological support in the use of VR/AR technologies (Matome & Jantjies, 2021).
10	Lack of proper performance monitoring	Most higher education institutions do not have a system for assessing the impact of digital technologies on the quality of education (Babenko, Dotsenko & Gorbenko, 2022).

Source: created by the author based on Babenko, Dotsenko & Gorbenko (2022), Benavides et al. (2020), Jemni et al. (2024), Kapranov, Bokhonko & Cherednyk (2022), Matome & Jantjies (2021), Matviichuk et al. (2021), Mojumder, Uddin & Dey (2025), Nesterenko et al. (2024), Reimers & Marmolejo (2022), Vovk (2020).

The identified problems indicate the need for a comprehensive approach to the digitalization of higher education institutions, including not only technical equipment but also the development of digital culture, adaptation of educational programs, and the creation of a unified digital infrastructure. Only systemic changes, supported at the state level and implemented at the institutional level of each institution, will create an effective digital environment that will improve the quality of the educational process.

The study was conducted at the National University of Life and Environmental Sciences of Ukraine in February 2025. The survey involved 220 undergraduate students of various specialties and 80 teachers of the departments of humanities, engineering and natural sciences. The sample was formed on the basis of voluntary participation, and the survey was conducted remotely using Google Forms. The questionnaire consisted of four thematic blocks aimed at assessing the impact of digital technologies on access to educational materials, the level of feedback between students and teachers, student engagement in the educational process, and teachers' self-assessment of digital competencies. The collected data were processed using quantitative analysis methods, and the results are presented in the form of a summary table and generalized averages. The results of the study are presented in Figures 1 and 2.

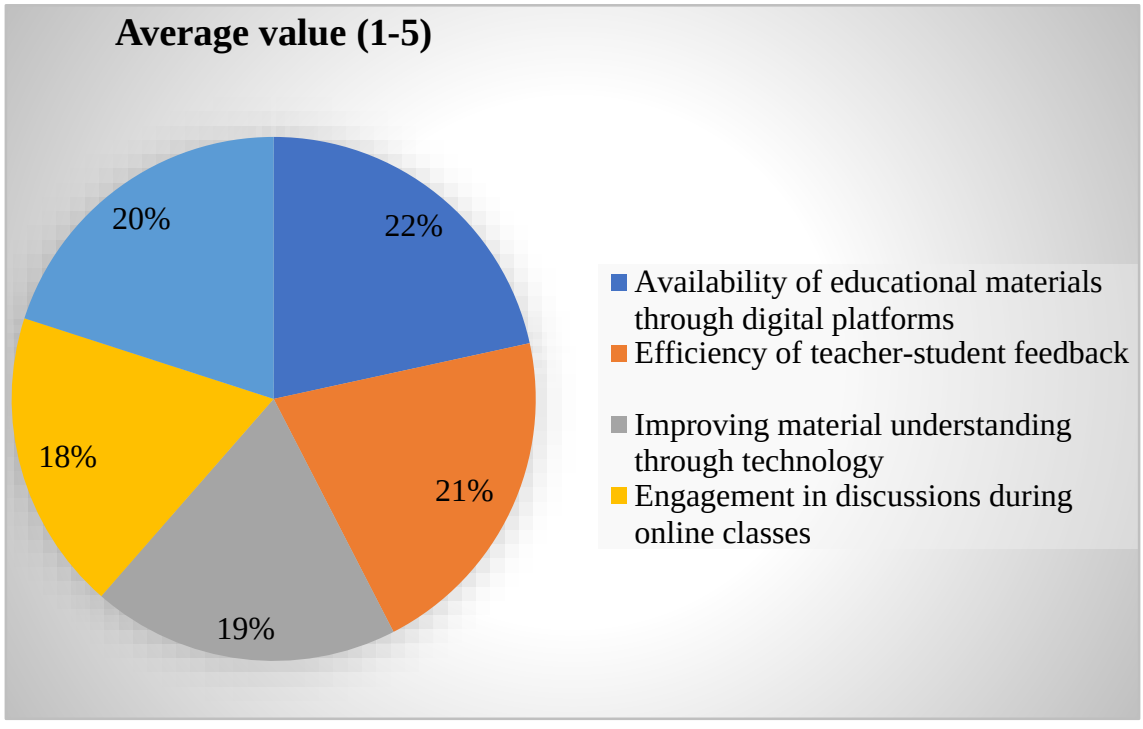

Figure 1. Evaluation of the impact of digital technologies (Student survey results)

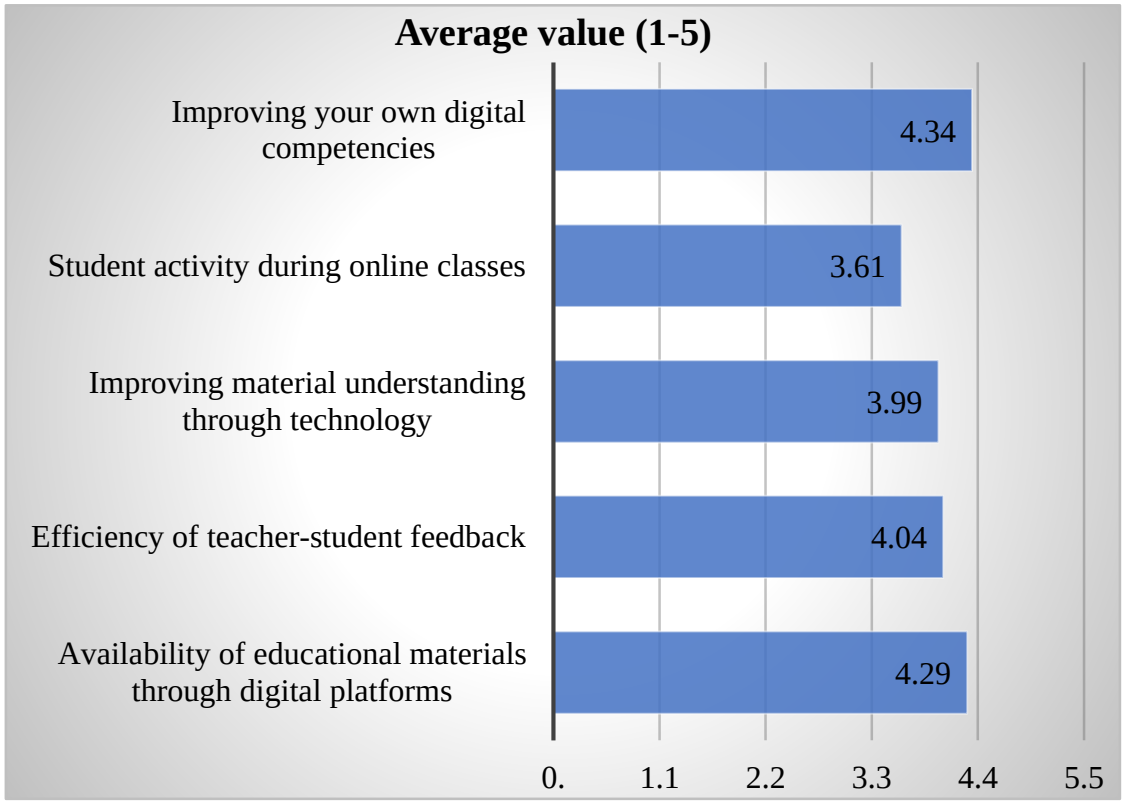

Figure 2. Evaluation of the impact of digital technologies (Results of the survey of teachers)

The results of the survey of students and teachers of the National University of Life and Environmental Sciences of Ukraine showed a generally positive perception of the introduction of digital technologies in the educational process, but a detailed analysis revealed certain differences in the perception of certain aspects.

1. Access to learning materials. Students rated the improvement of access to learning materials at 4.41 points, which indicates the high efficiency of using digital platforms to provide learning content. Teachers are somewhat more reserved in their assessments - 4.29 points, which may indicate an awareness of technical or organizational difficulties related to downloading materials, standardizing their formats, etc. Overall, both groups recognize that technology has significantly expanded access to learning resources.

2. Feedback between teachers and students. The indicator of promptness of feedback received a high score of 4.26 points from students, which indicates a positive impact of digital platforms on the speed of communication with teachers. Teachers gave a slightly lower score of 4.04 points, which may indicate a higher workload of teachers or technical difficulties in ensuring constant online communication, especially in the context of mass distance learning.

3. Understanding of the learning material. It is interesting that students rated the impact of technology on improving their understanding of the course material relatively low - only 3.88 points. This may indicate that digital platforms alone do not guarantee a deeper understanding of

the material without proper methodological support. Teachers, on the other hand, scored this indicator somewhat higher - 3.99 points, which may indicate their confidence in teaching methods adapted to digital formats. Thus, there is a certain gap between students' expectations and teachers' vision of the effectiveness of digital technologies in learning.

4. Student involvement in the learning process. The level of student engagement in online discussions was rated by students at 3.79 points, while teachers rated it at only 3.61 points. This indicates a somewhat overestimated perception of their own activity by students and a more critical view of the level of student participation in online discussions by teachers. Such a gap is typical for distance learning, where passive presence is often perceived by students as participation.

5. Independent work and digital competencies. Digital technologies have significantly intensified students' independent work with learning resources - the average score was 4.09 points, indicating the growing importance of online libraries, video lectures, tests, and interactive materials. Teachers, in turn, highly appreciated their own growth in digital competencies - 4.34 points, which indicates their willingness to adapt to the digital environment and learn new tools.

The overall analysis shows a positive impact of digital technologies on the educational process, particularly in terms of access to materials and efficiency of communication. At the same time, student engagement and the effectiveness of understanding the material do not yet reach the expected levels, which may indicate the need to further improve online teaching methods, gamification, and interactive technologies (Yu & Wang, 2024). It is interesting to note that teachers highly appreciated their own progress in digital competencies, which demonstrates the positive impact of professional development programs and internal trainings in HEIs (Batsurovska et al., 2021). This creates a solid foundation for further digital transformation of the educational process. Thus, the digitalization of education is already shaping a new culture of interaction and learning, but requires a further balance between technological tools and pedagogical innovations (Benavides et al., 2020).

The digitalization of higher education is becoming global, and the world's leading universities are actively developing and implementing innovative digital tools to improve the quality of education, personalize the educational process, and ensure flexibility of learning. An analysis of the experience of different countries (see Table 2) allows us to identify effective approaches to the digital transformation of education and adapt them to the national realities of Ukraine. Particular attention is drawn to integrated digital learning management systems, the use of artificial intelligence, and the development of interactive learning platforms that promote active student engagement.

Table 2. Best practices for implementing digital tools in higher education institutions in different countries

№	Country.	University / System	Digital tools and practices	Features and achievements
1	USA	Massachusetts Institute of Technology (MIT)	MITx (EdX) platform, hybrid courses, virtual laboratories	Massive use of open online courses (MOOCs), integration of real cases into digital courses (Montgomery, 2020)
2	United Kingdom	Open University	Fully remote model, personalized learning platforms, Learning Analytics	Largest distance education university in Europe, using performance data to personalize learning (Benavides et al., 2020)
3	Finland	University of Helsinki	Moodle, gamification, interactive tests and simulations	Emphasis on interactivity and practical skills development through digital platforms (Kerimbayev et al., 2023)
4	Singapore	National University of Singapore	Adaptive learning management systems, augmented reality (AR), cloud platforms	Emphasis on artificial intelligence technologies for personalization of learning, use of AR for engineering disciplines (Woo, 2024)
5	China	Tsinghua University	Artificial intelligence (AI) integration, online simulations, automated tests	Automated assessment of written works, adaptive tests based on AI (Yu & Wang, 2024)

№	Country.	University / System	Digital tools and practices	Features and achievements
6	Germany	Ludwig Maximilian University of Munich	Integrated LMS system, online libraries, digital simulators	Combining scientific research and digital platforms to train future scientists (Reimers & Marmolejo, 2022)
7	South Korea	Korea Advanced Institute of Science and Technology (KAIST)	Virtual laboratories, 3D modeling, integration of VR/AR into training courses	Widespread use of virtual simulations in technical specialties (Matome & Jantjies, 2021)
8	Canada	University of Toronto	Integration of cloud services, electronic student portfolios, online classes	Formation of digital skills through cloud platforms Google Workspace and Microsoft Teams (Babenko, Dotsenko & Gorbenko, 2022)
9	UAE	University of Sharjah	Smart Campus System, artificial intelligence in monitoring student progress	Integration of digital technologies into administration and education (Jemni et al., 2024)
10	Australia	University of Melbourne	Blended learning, VR technologies for medical disciplines, adaptive tests	Adaptation of digital technologies to different levels of student learning (Tan, Rudolph & Tan, 2024)

Source: created by the author based on Babenko, Dotsenko & Gorbenko (2022), Benavides et al. (2020), Jemni et al. (2024), Kerimbayev et al. (2023), Matome & Jantjies (2021), Montgomery (2020), Reimers & Marmolejo (2022), Tan, Rudolph & Tan (2024), Woo (2024), Yu & Wang (2024).

Review of the experience of the world's top universities reveals that providing actual digitalization of education has nothing to do with technical support of the educational process itself, but also with creating the single digital ecosystem, which integrally combines the

educational, the administrative, the communicative, and the commercial function of the educational process. Especially in this sense are elements such as the personalization of learning with the use of Learning analytics and artificial intelligence, introduction of virtual laboratories and the simulations, as well as the active use of gamification to raise the motivation of the students. Taking these practices into account when developing national strategies for the digitalization of education in Ukraine will improve the quality of education, promote the development of digital competencies, and create competitive specialists for the global labor market.

The catalyst for higher education's digital transformation of around the world has been a very powerful one: the COVID-19 pandemic. Given the urgency of switching educational institutions to distance learning, it was inevitable for massive use of communication platforms online, learning management systems (LMS), creation of digital educational resources, and online exams. (Reimers & Marmolejo, 2022). According to international research, in 2020-2021, the share of universities that fully switched to the online format increased from 15% to 83% (Benavides et al., 2020). In Ukraine, this figure has reached about 92% among public HEIs (Matviichuk et al., 2021), although the level of technological readiness has been uneven.

The main areas of change included:

- Massive implementation of LMS systems (Moodle, Google Classroom).
- Use of Zoom, Microsoft Teams, Cisco Webex for conducting classes.
- Intensification of work on the creation of digital training courses.
- Increased interest in digital certification programs for teachers.

The COVID-19 pandemic has become a global catalyst for digital transformation in higher education, forcing educational institutions around the world to adapt their learning processes to distance and blended learning formats. In 2020, universities that had only partially implemented digital technologies before the pandemic were forced to urgently develop comprehensive online learning systems, master new platforms, and radically change pedagogical approaches. Figure 3 shows the dynamics of the introduction of key digital tools and processes in higher education institutions in 2018-2024, demonstrating how the pandemic has affected the digitalization of education, as well as what trends are observed in the post-pandemic period.

To assess the impact of the COVID-19 pandemic on the acceleration of digitalization in higher education, an analysis of reports, statistics and scientific publications on the functioning of higher education institutions in 2018-2024 was conducted. Particular attention was paid to the use of learning management systems (LMS), online classes, and the development of teachers' digital competencies. The collected data allowed us to build a dynamic model that reflects the scale and sustainability of changes in the digital educational environment both during the pandemic and in the post-pandemic period.

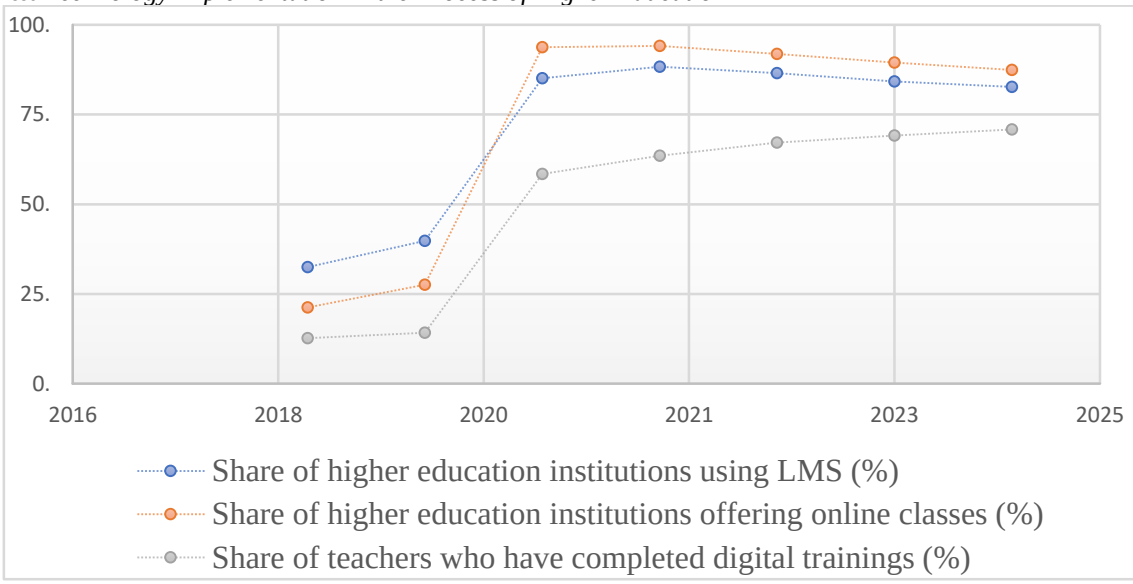

Figure 3. Dynamics of digital technology use during the COVID-19 pandemic

Source: created by the author based on Babenko, Dotsenko & Gorbenko (2022), Benavides et al. (2020), Jemni et al. (2024), Matviichuk et al. (2021), Reimers & Marmolejo (2022), Mojumder, Uddin & Dey (2025).

In 2018, only a third of universities (32.5%) actively used learning management systems (LMS), while in 2020 this figure increased to 85.1%. This more than twofold jump indicates the critical dependence of the educational process on digital platforms during the lockdown period. In the following years, the share of universities using LMS remained consistently high at over 80%, although with a slight downward trend after the quarantine restrictions were lifted. This shows that even after the return to blended learning formats, digital platforms have become an integral part of the educational process.

The dynamics of online classes is even more revealing. While in 2018, only 21.3% of educational institutions offered online classes, in 2020, the figure was 93.7%. In fact, all universities were forced to switch to distance learning, which was unprecedented in the modern history of education. After the pandemic, this figure is gradually decreasing (to 87.4% in 2024), but it is significantly higher than the pre-quarantine level, which indicates that mixed learning formats are becoming a regular practice.

It is worth noting the dynamics of teacher training in the field of digital technologies. Prior to the pandemic, only about 12.7% of teachers took digital trainings (2018), while in 2020 this figure increased to 58.4%, and in 2024 it reached 70.8%. This trend indicates a gradual change in the digital culture in higher education institutions, where teachers are already aware of the need to continuously improve their digital competencies. This is especially important given the development of artificial intelligence and new educational technologies that require teachers to have a deep understanding of the principles of their application.

Thus, the analysis allows us to highlight several key conclusions:

- The COVID-19 pandemic has created a powerful impetus for digitalization, the effect of which persists even in the post-pandemic period.

- The introduction of digital platforms has become a standard for most universities, regardless of specialization or geographic location.

- Despite the gradual decline in the share of online classes, blended learning formats have become established as the best option for organizing education.

- The level of digital literacy of teachers has increased significantly, which creates the preconditions for further development of innovative teaching methods and integration of technology into the traditional educational process.

Thus, the COVID-19 pandemic has not only accelerated the integration of digital technologies into higher education, but also launched irreversible processes of developing digital competencies, transforming the educational environment, and introducing flexible learning models. Digitalization has become a strategic priority for universities around the world, and the experience gained during the pandemic is an important basis for further modernization of higher education, including in Ukraine.

Here are four recommendations for improving the efficiency of technology integration in higher education, taking into account the needs of modern students and teachers:

1. Develop a unified digital educational ecosystem at the level of each higher education institution that will ensure the integration of learning platforms, online courses, digital libraries, progress monitoring systems, and communication tools to create a comfortable digital learning environment.

2. Ensure systematic improvement of digital competencies of teachers and students through regular trainings, consultations and access to relevant methodological materials on the use of modern digital tools in the educational process.

3. Introduce personalized learning approaches using elements of artificial intelligence, adaptive systems, and learning data analytics to individualize learning paths according to the needs of each student.

4. Develop blended learning formats, combining online tools with classroom work to ensure a balance between technological capabilities and live communication between teachers and students.

Discussion

The findings of the study confirmed the global trend towards the active introduction of digital technologies in higher education institutions, which was largely accelerated by the COVID-19 pandemic. In particular, it was found that both students and teachers positively assess the impact of digital tools on the availability of educational materials and the efficiency of feedback, but note certain difficulties in ensuring active student participation and improving the quality of learning in the digital environment.

The position of Ukrainian researchers (Babenko, Dotsenko & Gorbenko, 2022; Matviichuk et al., 2021) is largely consistent with our findings, as they emphasize that the introduction of LMS

systems and video conferencing platforms has indeed improved communication and access to materials. However, according to Kapranov, Bokhonko, and Cherednyk (2022), the low level of digital competencies of some teachers significantly complicated the quality implementation of distance learning formats, which was partially reflected in our study. This was especially evident in the mismatch of curricula with the realities of online education and insufficient methodological support for teachers in the process of adapting to digital platforms.

At the same time, foreign researchers, such as Reimers and Marmolejo (2022), view digitalization as an inevitable stage in the evolution of education, emphasizing the need for teachers to develop digital pedagogy skills and design digital courses based on active learning methods. They emphasize that the quality of the digital learning environment depends not only on technical equipment but also on the willingness of participants in the educational process to accept new roles and learning formats.

In our study, students highly appreciated the access to materials and the convenience of independent work in the digital environment, which correlates with the findings of Benavides et al. (2020), who emphasize the positive impact of digital libraries, interactive platforms, and adaptive tests on the learning process. However, Yu and Wang (2024) point out that without proper pedagogical support, even the most advanced technologies do not guarantee an increase in the quality of knowledge acquisition. This thesis is confirmed by the relatively low assessment of the impact of technology on the depth of understanding of the educational material by students in our survey.

On the other hand, researchers such as Matome and Jantjies (2021) emphasize the great potential of virtual and augmented reality for developing the practical skills of technical students. In Ukraine, such practices are just beginning to spread, and our results do not yet provide grounds to talk about their massive positive impact. This suggests that VR/AR technologies require significant investment and methodological support, which is confirmed by the research of Soloviev et al. (2021).

Thus, the results largely confirm the hypothesis of the positive impact of digital technologies on the quality of the educational process, although their effectiveness largely depends on the level of digital competencies of teachers and the adaptation of curricula to the new format. The most obvious benefits include increased access to learning materials, prompt feedback, and flexible learning environments, which is especially important in crisis situations such as the COVID-19 pandemic.

However, it should be noted that the study has certain limitations. It covers only one university (the National University of Life and Environmental Sciences of Ukraine) and focuses mainly on subjective assessments of participants in the educational process, which may limit the generalization of the results to the entire higher education system of Ukraine. Further research should focus on analyzing the effectiveness of specific digital tools in different subject areas and assessing their impact on students' academic achievement using objective methods of monitoring learning outcomes.

Conclusions and Prospects for Further Research

The results of the study confirm that digital technologies significantly change the structure and dynamics of the educational process in Ukrainian higher education institutions, but the effectiveness of their use depends not only on technical support but also on the level of digital

culture of the participants in the educational process. Contrary to the initial assumptions that the main barrier to digitalization would be the lack of material and technical resources, in practice, the key problems were low methodological readiness of teachers, fragmentation of technology implementation, and the lack of a single digital ecosystem. The novelty of the study lies in the combination of quantitative analysis of students' and teachers' opinions with a comparative analysis of international experience, which allowed us to identify both general trends and specific problems for the Ukrainian educational environment. The practical significance of the findings lies in the possibility of using them to improve internal digitalization policies at universities, develop programs to improve teachers' digital competencies, and adapt curricula to blended learning. The main limitations of the study include the focus on a single educational institution, which reduces the possibility of fully reflecting regional and sectoral differences, as well as the use of mainly subjective assessments of participants in the educational process without the involvement of objective indicators of academic performance. Further research should be aimed at developing models of digital ecosystems for different types of educational institutions, studying the impact of specific digital tools on the formation of professional competencies in various fields of knowledge, and analyzing the effectiveness of implementing adaptive learning with the use of artificial intelligence and Learning Analytics. It is promising to study the impact of digital technologies on the development of students' soft skills and the formation of digital thinking among teachers, which will create a holistic concept of digital transformation of higher education in Ukraine.

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Appendix A
Questionnaire
Block 1. General information

1. Your status:
   □ Student □ Teacher
2. Your field of study (for students) or discipline (for teachers):
3. Experience in using digital technologies in the educational process:
   □ Less than 1 year □ 1-3 years □ More than 3 years

Block 2. Assessment of the impact of digital technologies on the quality of education (5-point scale)

4. Do digital platforms (LMS, Zoom, Moodle, etc.) improve access to learning materials? □ 1 □ 2 □ 3 □ 4 □ 5
5. Has the efficiency of feedback between teacher and student increased? □ 1 □ 2 □ 3 □ 4 □ 5
6. Does the use of technology contribute to a better understanding of the material? □ 1 □ 2 □ 3 □ 4 □ 5

Block 3. Student engagement (5-point scale)

7. Have you (or your students) become more active in discussions during online classes? □ 1 □ 2 □ 3 □ 4 □ 5
8. Has the amount of independent work with digital resources increased? □ 1 □ 2 □ 3 □ 4 □ 5

Block 4: Digital competencies of teachers (5-point scale)

9. Have your (or your colleagues') skills in working with digital platforms increased over the past 3 years?
   □ 1 □ 2 □ 3 □ 4 □ 5
10. Have you (or your colleagues) attended any trainings or courses on digital literacy?
    □ Так
    □ Ні